ALTERNATIVE DESIGN OF MANIPULATOR FOR MAINTENANCE WORK IN HAZARDOUS ENVIRONMENT

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
In
Mechanical Engineering

By

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CERTIFICATE

This is to certify that the project entitled, "**Alternative design Of Manipulator for maintenance work in hazardous environment** " submitted by Deepak Kumar in partial fulfillment of the requirements for the award of Bachelor of Technology, National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the project report has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date:

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ACKNOWLEDGEMENT

I would like to articulate my deep gratitude to my project guide Prof. B.B.Biswal who has always been my motivation for carrying out the project.

An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in reference section. I acknowledge my indebtedness to all of them.

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ABSTRACT

The project "**Alternative Design of Manipulator for Maintenance Work in Hazardous Environment**" is basically aimed towards bringing and replacing the needle clip valve assembly from a radioactive region. Under guidance of Prof. B.B.Biswal the project is destined as a great success.

In a remote handling area for research and analysis we have to pick up certain samples from that surrounding or place some devices for monitoring. An unmanned Robotic vehicle can serve this purpose, but a lot of obstacles will be present in the path of the robot so it has to be so smart enough to avoid such obstacles. We have designed the Remote handling mechanism which will help it to move to the spot without getting damaged and carry out the given task successfully.

Different Remote Handling Mechanisms are conceptualized, studied & designed in SOLIDWORKS and a comparative studied is completed.

Chapter 1

INTRODUCTION

1.1- INTRODUCTION TO ROBOTICS

The term ‘ROBOTICS’ was coined by ISSAC ASIMOV in about 1940.The origin of word robot came around in 1917 and was first used by KAREL CAPEK.

The definition of ‘ROBOT’ as supplied by the institute of America is a reprogrammable multifunctional manipulator, devised for the transport of the materials, parts, tools or specialized items with varied and programmed movements, with the aim of carrying various tasks”.

Robotics is a very fascinating and vast field .Availability of numerous ways of actuation, application; gaits etc .In a vast field needs detailed study. Choice of robotic motion was influenced by the intrinsic involvement of mechanical engineering for its study and development .Robotic motion is possible in various ways with different modes of actuation, basic motion, application, terrain, etc.

The major application areas of Robots can be categorized as follows:-

1. Material handling.
   a. -Moving parts from warehouse to machines
   b. -Transporting explosive device.
2. Machine loading and unloading -Loading of gears on to C.N.C lathes.
3. Spray painting.
4. Machining - Drilling aluminum panes on aircraft.
5. Assembly of aircrafts parts.
6. Maintenance of nuclear reactors.
7. Mechanical handling and monitoring of radioactive elements.
8. Decontamination of nuclear wastes developed by various processes.
9. Reactor decommissioning.
10. Transport of Radioactive material.

1.2- INTRODUCTION TO MANIPULATORS

A manipulator is a device used under human control to manipulate materials without direct contact. The materials are frequently radioactive or biohazardous.

1.2.1: Classification of the Manipulators

The manipulator may be classified as follows:

1. According to distance from work.
2. According to task.
3. According to mechanism of the manipulator.
4. According to control technology.
5. Classification by man-machine interface.

1.2.1.1: According to distance from work

- Master slave manipulators are characterized by their short working distance.
- Mobile teleportation systems are used for greater working distances.
  Example: Servo control manipulators motorized control.

1.2.1.2: According to task

- This classification includes relative variations in geometrical scale between the volume in which the operator is working and the volume in which the task is executed.
- Mechanical master slave manipulator are classified as scale 1 (with maximum up to 1.3 or 1.6)
- Servo master slave manipulators have a linear ratio of 1 or less and between 8 and 10, which is highest to date.
- This technology enables linear scaling to be combined with variable slave to force ratio.

1.2.1.3: According to the mechanism of the Manipulator

It is based on two criteria:

1. Manipulators with mechanisms that are driven entirely by the user.
2. Other criteria are concerned with manipulators that are driven by power from power source.
   Example: Electric, hydraulics, pneumatic, etc.

1.2.1.4: According to control technology

By control technology the manipulators are classified as:

1. Integrated Control.
2. Analytical Control.

Integrated Control: In this type a single device, sometimes known as the sensor receives all the information input from the operator.

Analytical Control: In this type each control lever corresponds to one type of action depending upon its movement.

1.2.1.5: Classification by man-machine interface

This classification depends upon whether there is information feedback to the hand of the operator i.e. on the muscular level or only feedback information of visual, sound or other information.

1.3 - Application of Robots in hazardous environment

Robots, whether teleported, under supervisory control, or autonomous, have been used in a variety of applications in maintenance and repair. The following subsections describe many of these systems, focusing primarily on applications for which working robot prototypes have been developed.

1.3.1:- Nuclear Industry

In Nuclear industry the robots are mostly used for the following ways:-

a. Operation and maintenance of industrial nuclear facilities and laboratories.
b. Maintenance in nuclear reactors.
c. Decommissioning and Dismantling Nuclear Facilities.
d. Emergency intervention.

1.3.2:- Railways

1.3.3:- Power line maintenance

1.3.4: - Aircraft Servicing.

1.3.5:- Underwater Facilities.

1.3.6:- Coke Ovens

Chapter 2

PROBLEM STATEMENT

The main objective of our mechanism is handling of needle clip valve assembly in a radioactive zone. The remote handling mechanism has to take out the needle clip valve assembly from the remote area and then replace it with a new needle clip valve assembly.

The needle- clip valve mechanism is inside a blister box which is at a distance of 550mm from the top cover of the box. There will be ten such needle- clip valve assemblies which are fixed on to a projection from the wall of the box with two screws. It is accessible from the top portion only as there is an opening of 630 X 126. This opening is covered by lead block which are used for shielding radiation. Above the cover 385mm space is available. The specification of a single needle clip valve is shown in Fig 1.

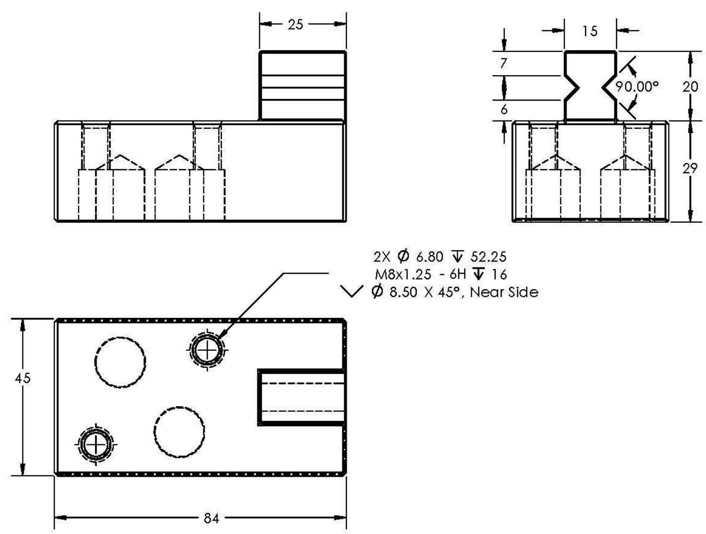


Fig1: A layout of a single Needle clip – valve mechanism

In a set of 10 Needle-clip valve assemblies, every assembly is separated from each other by 63 mm from centre to centre and the distance between the two assemblies is 18 mm. All of these Needle-clip valve assemblies are arranged in a synchronized way. Fig 2 give us an view of the over all assemblies.

The needle- clip valve assembly needs periodic replacement with a fresh assembly. The assembly is screwed to a holder base with specially designed bolts. Hence the objective here becomes to gain access to the Needle-clip valve assembly, hold it, unscrew the bolts, bring it back outside of the cell and then replace it with a fresh product in the same position.

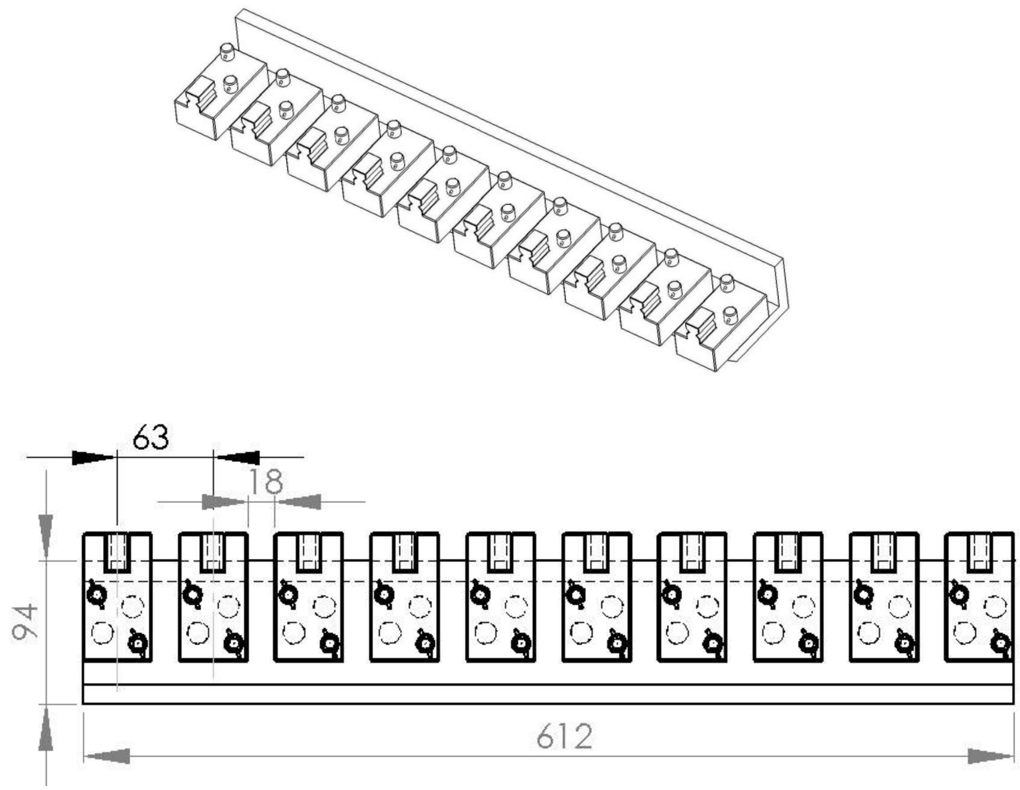


Fig2: A set of 10 Needle clip – valve assemblies with details

The mechanism has to be built within a height of 385mm which will travel vertically a distance of 550mm. There are also constraints while entering into the box is where the free space provide is 122x109m. The layout of blister box inside which contain needle clip valve assembly is presented in Fig 3.

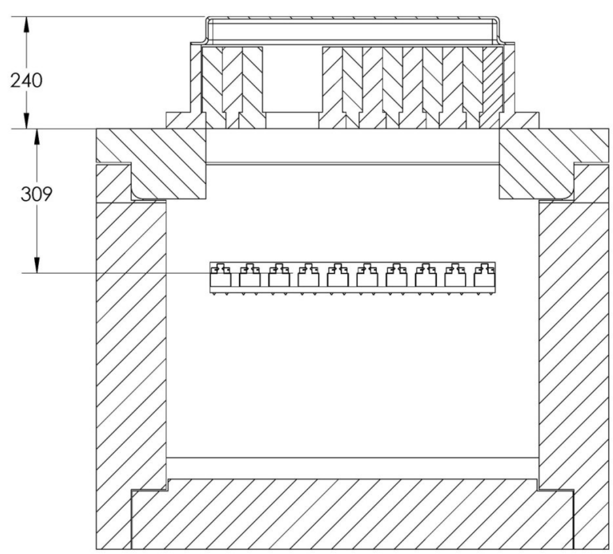


Fig3: Blister Box

Chapter 3

Proposed Designs

For achieving the desired requirement we have designed a mechanism which basically consists of mainly four parts:-

1. Horizontal motion arrangement.
2. Vertical movement arrangement.
3. Gripping arrangement.
4. Unscrewing arrangement.

The horizontal motion arrangement consists of LM-Guide way and Ball screw assembly, which help the remote handling mechanism to achieve the desire motion in horizontal direction. Different proposed mechanism will go inside by vertical movement arrangement. Our mechanisms consist of an unscrewing arrangement which will unscrew the Needle-clip valve assembly. We have also made some projection on the Needle-clip valve assembly so that gripper will hold it. For accurate positioning we are using Proximity sensors. The accurate positioning will be done form the outside by the LM guide. After bringing the needle- clip valve assembly to the required position outside the blister box by the proposed model we will replace it by a fresh assembly.

For replacing the component from the desired position we came out with different type of solution. The pneumatic gripper portion (for holding the component), the unscrewing arrangement (for opening the screw mounted on the component) and the upper LM guide arrangement (for horizontal motion) are going to remain almost same in all the mechanism. These different type of remote handling mechanism are describe according to there way to reach the desire position in the blister box. Different types of manipulator designs are as follows:-

1. Design 1 (Containing 4 Pneumatic cylinders)
2. Design2 (Containing 2 Pneumatic linear drive (Rod less) and one pneumatic cylinder).
3. Design 3 (Robotic arm mechanism)
4. Design 4 (Scissor mechanism)
5. Design 5 (Telescopic tube mechanism)

3.1- Working Principle:

The working principle of all the mechanisms are almost the same except the fact that the vertical movement is carried out considering different mechanisms. So the name of a whole mechanism is essentially given by the name of vertical assembly.

Chapter 4

LM GUIDEWAYS

LM-Guide as the name suggests is used for highly precise linear motion. It can sustain high loads in any direction and hence can be mounted in any direction. The assembly contains a rail which guides a block on it. Inside the block, ball or roller are present which drastically reduces the frictional losses. So LM-Guide is preferred in both industries and robotics to achieve specific functions. A simple layout of a general LM guide is given in Fig 4.

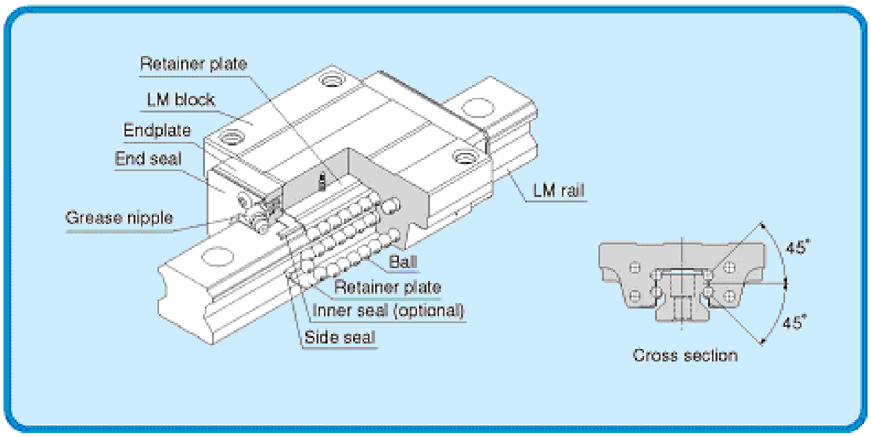


Fig4 : A simple layout of LM Guides

4.1- Structure and Features

Balls roll in four rows of raceways precision-ground on an LM rail and an LM block, and end-plates incorporated in the LM block allow the balls to circulate. Since retainer plates hold the balls, they do not fall off even if the LM rail is pulled out (except models HSR 8, 10 and 12). Each row of balls is placed at a contact angle of 45°so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse-radial and lateral directions), enabling the LM Guide to be used in all orientations. In addition, the LM block can receive a well-bal-anced preload, increasing the rigidity in the four directions while maintaining a constant, low friction coefficient. With the low sectional height and the high rigidity design of the LM block, this model achieves highly accurate and stable linear motion.

4.1.1: 4-way equal load

Each row of balls is placed at a contact angle of 45°so that the rated loads applied to the LM block are uniform in the four directions (radial, reverse-radial and lateral directions), enabling the LM Guide to be used in all orientations and in extensive applications

4.1.2: High-rigidity type

Since balls are arranged in four rows in a well-balanced manner, a large preload can be applied and the rigidity in four directions can easily be increased.

4.1.3: High durability

Even under a preload or biased load, differential slip of balls does not occur. As a result, smooth motion, high wear resistance, and long-term maintenance of accuracy are achieved.

4.1.4: Rated Loads in All Directions

Model HSR is capable of receiving loads in all four directions: radial, reverse-radial and lateral directions. The basic load ratings are uniform in the four directions (radial, reverse-radial and lateral directions), and their actual values are provided in the dimensional table for HSR.

4.1.5: Equivalent Load

When the LM block of model HSR receives loads in the reverse-radial and lateral directions simultaneously, the equivalent load is obtained from the equation below.

PE＝PR（PL）＋PT Where, PE = Equivalent Load (N)

PR = Radial Load (N)

PL = reverse-radial Load (N)

PT = Lateral Load (N)

Our LM guide arrangement is consist of two LM guide (HSR 20 R 2 SS C0 M + 1100 L H M II) which move in desired direction on the ball screw (BNT 20 05 2.65 RR G0 + 900L C5 Y). the layout assembly of LM guide that we are using in our design in give in Fig 4.

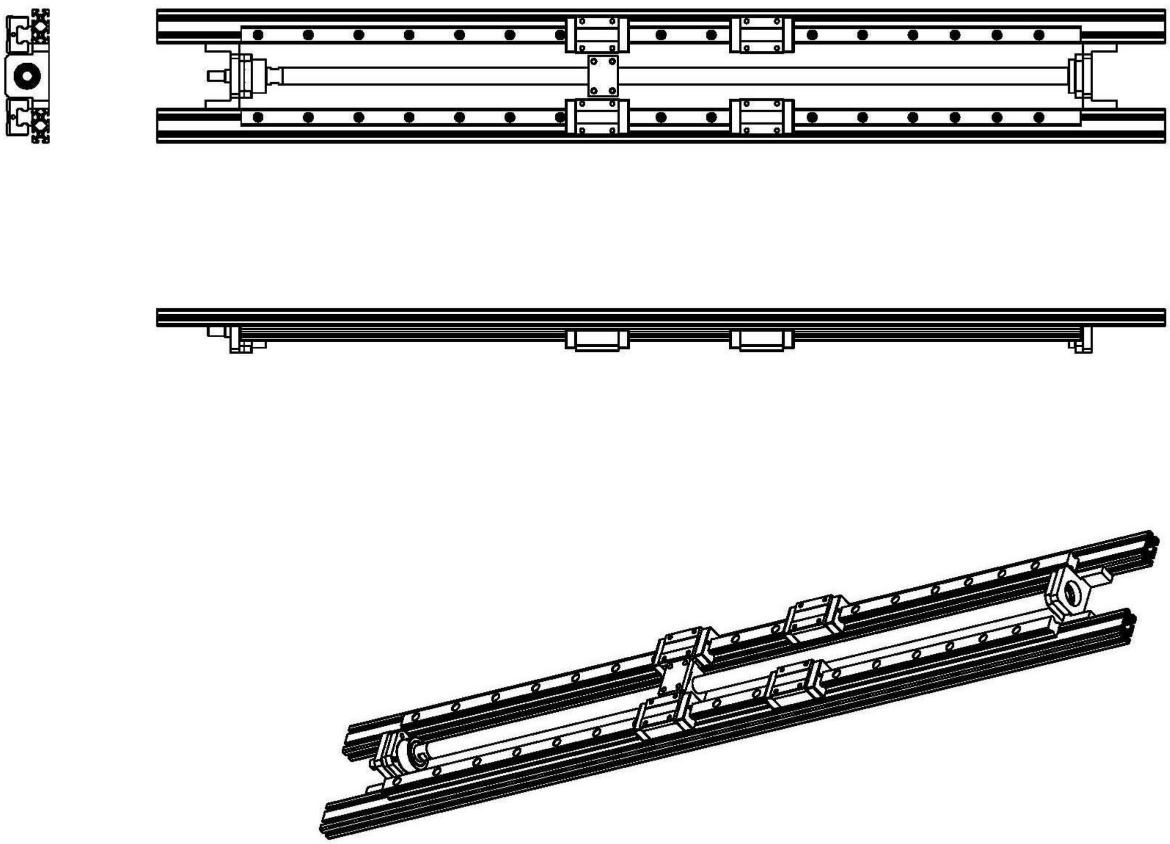
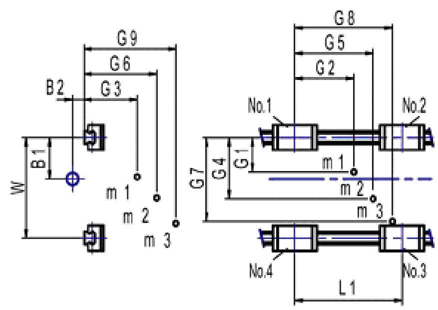
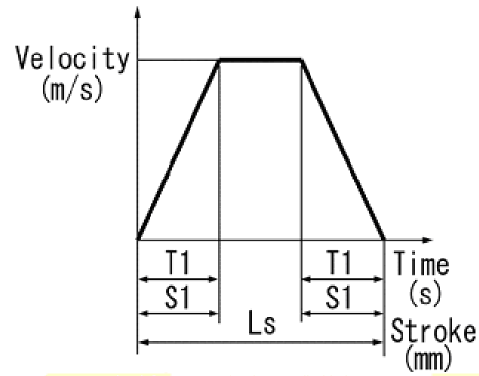


Fig5: Horizontal moving arrangement

4.2- Calculation of service life of LM Guide

Operating Condition





Mounting Orientation:		Wall-mounted application		Velocity:	V=	0.0025	m/s	Rail span(mm):	W=	98	
Model Number:		HSR20		Acceleration time:	T1=	0.5	s	Block span(mm):	L1=	206	
Basic dynamic load rating:	C=	13800	N	Load factor:	fw=	1.2			L2=	---	
Basic static load rating:	Co=	23800	N	Stroke length:	Ls=	300	mm		L3=	---	
Revised Coefficient:	$Ka_M R$=	---		Number of reciprocations per minute:	N1=	0.1	min^{-1}	Thrust point(mm):	B1=	49	
	$Ka_M L$=	---		Acceleration:	α=	0.005	m/s^2		B2=	-6	
	Kb_M=	---		Acceleration,Deceleration:	S1=	0.63	mm	Block width(mm):	BW=	44	
				Velocity:	S2=	298.75	mm	Block length(mm):	BL=	74	
Mass(kg)	m1=	10	m2=	0	m3=	0					
Gravity points(mm)	G1=	150	G2=	103	G3=	78	G4=	0	G5=	0	
	G6=	0	G7=	0	G8=	0	G9=	0			

Calculation Result

Applied load(N)

		No.1	No.2	No.3	No.4		
						Static safety factor	
						fs=	**422.6**
(1) During acceleration	Radial direction	-31.8	-31.8	31.8	31.8	**Nominal life**	
	Horizontal direction	24.5	24.5	24.5	24.5	**L=**	**4.26E+08 km**
	Equivalent load	56	56	56	56	**Service life time**	
(2) In uniform motion	Radial direction	-31.8	-31.8	31.8	31.8	**Lh=**	**1.18E+11 h**
	Horizontal direction	24.5	24.5	24.5	24.5		
	Equivalent load	56	56	56	56		
(3) During deceleration	Radial direction	-31.8	-31.8	31.8	31.8		
	Horizontal direction	24.5	24.5	24.5	24.5		
	Equivalent load	56	56	56	56		
(4) Mean load	Pm=	56 N					

This table gives us an idea about the operating condition and different necessary parameters that are required to develop the LM guide for given problem.

Table 2 give us the calculation result that is obtained by the current given conditions and LM guide service life time and Nominal life duration.

4.3- Selected LM guide
HSR 20 R 2 SS C0 M + 1100 L H M II

Significance of the code
HSR 20 R - Model no.
2 – Two rails
SS – end seal + side seal
C0 – radial clearance
M – Stainless steel material
1100 L – standard length (in mm)
H –accuracy grade
M- Stainless steel material
II – no. of axis

Basic dynamic load rating C = 13.8 KN
Basic static load rating C0 = 23.8 KN

4.4- Selected ball screw
BNT 20 05 2.65 RR G0 + 900L C5 Y
BNT - Model no.
20 –screw shaft diameter
05 – Lead
RR – Labyrinth seal attached to both ends of the ball screw nut
G0 – Axial clearance
900L – overall shaft length (in mm)
C5 – Accuracy symbol

4.5- Advantage of LM Guide
1. Smooth movement with no clearance.
2. High running precision with ease.
3. High rigidity in all direction.
4. High permissible load rating.
5. High long term precision.
6. High speed operation.

Chapter 5

PNEUMATIC GRIPPER

5.1- Selection of Gripper

The gripper is used for holding the needle clip valve assembly. The gripper is selected taking into the consideration total load of needle clip valve assembly. Also since the holding position of the grip is eccentric from the assembly moments are built up which is sufficient for the failure of an improperly selected gripper.

The selection process for the gripper was basically inclined towards pneumatic types due to its compact size which play an important role in our design process. The compact and low-cost parallel gripper consists of a two-part symmetrical housing. The piston moves traverse to the half-shell casing in an optimum housing design that guarantees reliable operation, long service life and convenient sensing. The gripper jaws move along the half shells in backlash-free, preloaded ball bearing guides. Layout of the pneumatic gripper is show in figure 6.

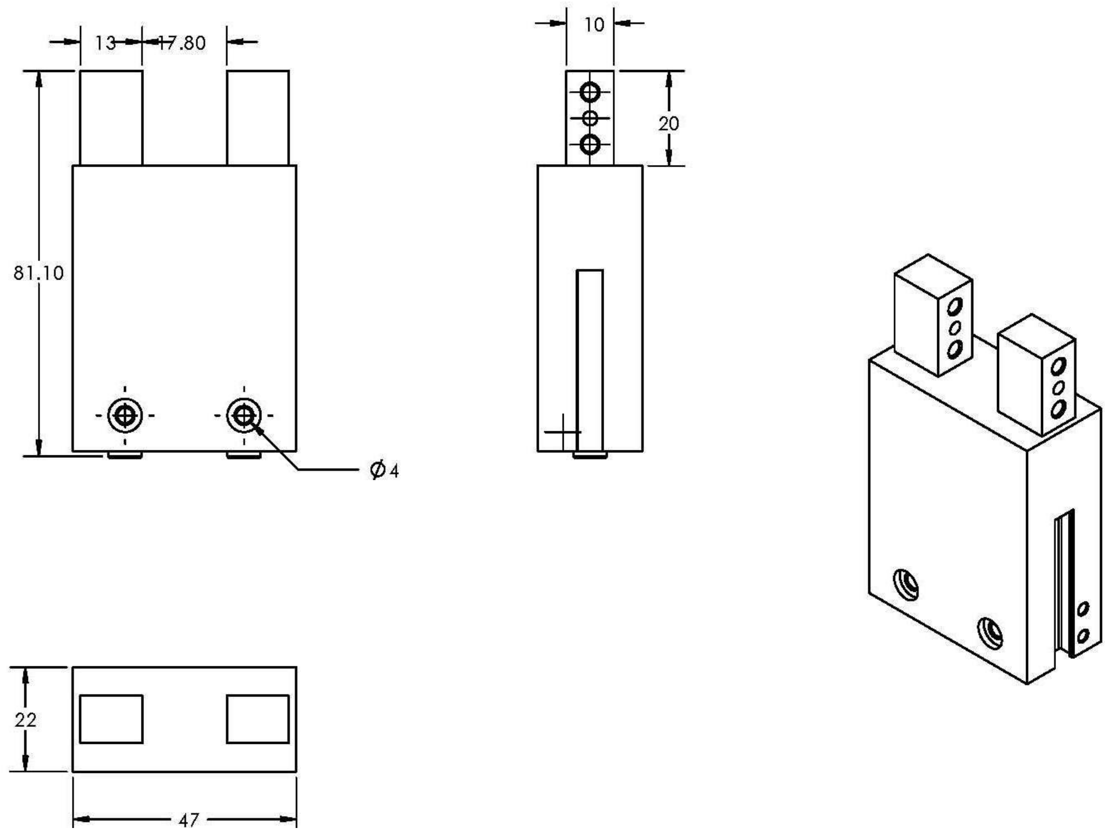


Fig 6: A layout of Pneumatic gripper

5.2-Parallel Gripper HGP-16-A-B-G2

Significance of the Code:

HGP - Parallel Gripper

16 - Size

A - For positioning sensing

B - Generation of B series

G2 - Gripping force retardation (G1 – Open & G2 – Closed)

Product description

Parallel gripper, HGP-16-A-B-G2

- Double acting piston drive
- Self – centering
- Variable gripping action (External / Internal gripping)
- Wide range of options for mounting on drive units
- High gripping force and compact size
- Maximum repetition accuracy
- Gripping force retention

- Internal fixed flow control
- protection dust cap for use in dusty environment
- Sensor technology (Adaptable proximity sensors on small gripper / Internal proximity sensors for medium and large gripper)

5.3- Calculation portion for the Pneumatic Gripper

Input data

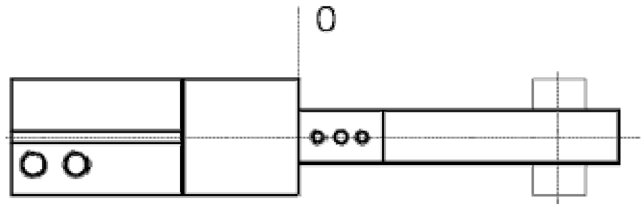


Fig 7: A side view of pneumatic gripper

Information about the object

Distance from 0-line (centre of gravity) - 35 mm

Weight of object (W) – 1000 gm

Required stroke – 10 mm

Data for a single finger

Weight of the one gripper finger – 35 g

Distance 0-line (centre of gravity) – 25 mm

Distance 0-line (gripping point) – 35 mm

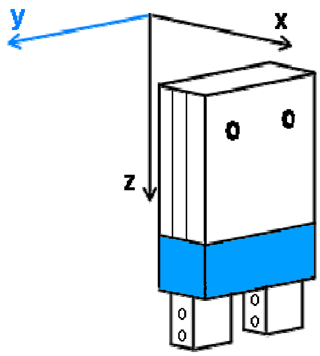


Fig 8: A isometric view of pneumatic gripper

Different view of the pneumatic gripper is given in the fig 7 & 8.

Information regarding the motion

Acceleration – Y direction

Maximum linear acceleration – 1 m/s^2

Mounting position

Gripper position –Vertical
Direction – Closing

Other specification
Working pressure – 6 bar
Frictional co-efficient (μ) = 0.5
Safety factor = 2
Device temperature – 20 °

Calculations of forces and moment:
Free body diagram of the job in show in the fig 9.
Normal force, N

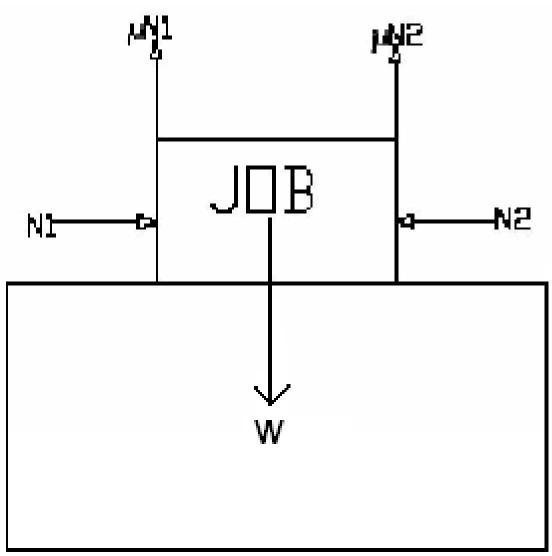


Fig 9: Free Body Diagram of Job

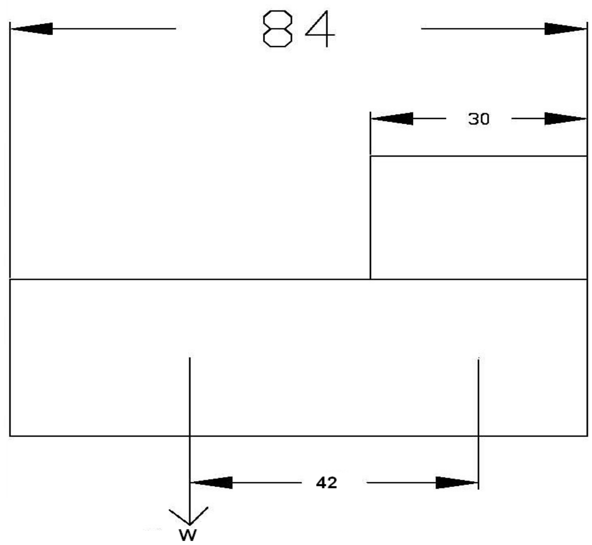
Balancing the forces in the X direction we get → $N_1 = N_2$ = N

Balancing the forces in the Y direction we get → $\mu N_1 + \mu N_2 = W$

Using the above two equations we get:

Normal force $N_1 = \frac{W}{2\mu}$ = 19.62 N

Dynamic Transverse Force, M_Y



Calculating the moment in the Y – direction

Weight of the Job (W) = 1000 gm

Distance at which moment occur = 42 mm

M_Y = Force * Distance

= (1 * 9.81) * .042

= 0.41 N-m

5.4- Obtained Data

Weight of the product – 197 gm

Overall stroke – 10 mm

Required static retention force = 19.62 N, Maximum possible = 59.68 N

Required dynamic retention force = 21.6 N, Maximum possible = 59.68 N

Intermediate distance of the pressure point = 40 mm, Maximum possible = 60 N

Dynamic longitudinal force on gripper finger = 5.25 N, Maximum possible = 90 N

Dynamic lateral force, M_x = 0.02 N-m, Maximum possible = 3.3 N-m

Dynamic transverse force, M_y = 0.41 N-m, Maximum possible = 3.3 N-m

Dynamic lateral torque, M_z = 0 N-m, Maximum possible = 3.3 N-m

Chapter 6

Unscrewing mechanism

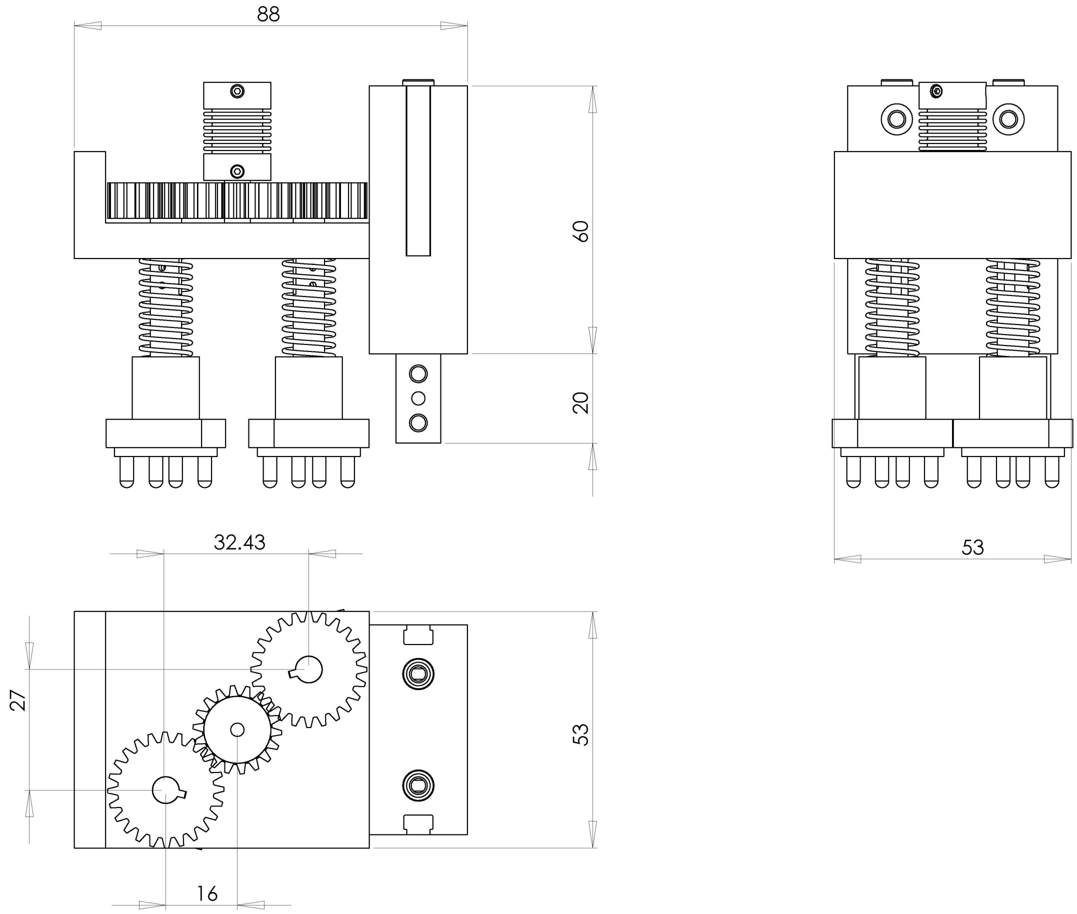


Fig 10: Layout of Unscrewing mechanism

6.1 - WORKING PRINCIPLE

After reaching the appropriate position from the top with the help of robot we will use the pneumatic gripper to hold the Needle-clip valve assembly and unscrew the screws. For unscrewing the screws we need rotary motion which is provided by a geared motor. The geared motor is clamped to the top portion of the plate where the gear arrangement is fixed. Rotational motion is transferred from the motor shaft to the gear1 with a flexible coupling. A layout o whole the assembly of unscrewing arrangement is given in Fig 10.

As we need to unscrew two screws so the gear1 is coupled to two steps down gear 2&3 which are identical. The two gears are connected to there respective shafts which were concentric with the screw axis of rotation. All the shafts are coupled to a thrust bearing which act as a link between the plate and gear shaft to provide relative rotational motion. Down the plate a compression coil spring is attached to act as a pushback mechanism when the spring is at its compressed position after unscrewing. The bottom end of the spring is attached to an internal spline shaft. The gear shaft will be having the reverse profile of a spline shaft so that the shaft will have relative linear motion as well as can transmit torque. The end portion of the two shafts is in the form of square. The will be clearance between the two square bases so they can provide some flexibility to the system while rotation.

The bottom part basically consists of a circular plate from the bottom side of which, 4 pins are attached at appropriate distance from the center so that they can cover the whole screw head. The screw head will also have 4 pins but perpendicular to the direction of the former. When the pins in bottom plate get engage between the pins of the latter and the motor is run, the rotational torque is transmitted from the shafts to the pin of gear head and the screw rotates.
During unscrewing the screw travels up as a result the whole arrangement travels up. This upward motion is adjusted by the compression of the coil spring. While early positioning it may happen that the bottom plate screws might get stuck on the screw head pins so for this problem the former pins have a hemispherical ends and some clearance is provided between the two square base ends of the shaft to have some rotary adjustment system.

6.2 - Products Specification
Motor Specification:
EC-max-22,12W with planetary gear head GP-22C Φ22 + MR encoder

Specification of ECmax-22
Brush less type, Order no.:283839
Nominal speed =7740rpm
Nominal torque=11.9mNm
Nominal voltage= 18V
Weight of motor=67g

Specification of planetary gear head GP-22
Order no.: 143991
Reduction available: 231:1
Number of stages: 4
Maximum efficiency=.49
Weight =22g

MR encoder
MR means magneto resistant

In a MR encoder, the multiple magnetic discs mounted on the motor shaft produces a sinusoidal voltage in MR sensor the typical encoder signals are created by interpolation and electronic signal refinement.

6.3 - Design of Components:

6.3.1 :-Gear design

From the figure 9 given below

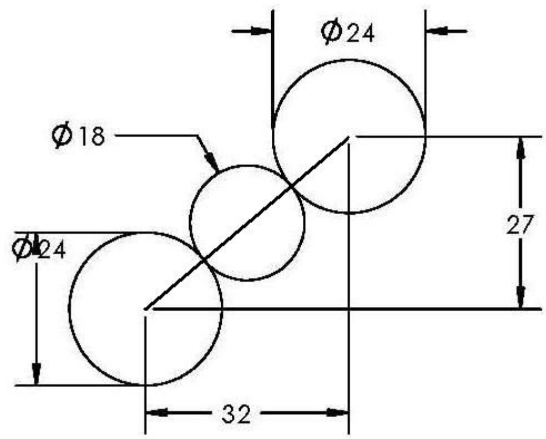


Fig 11: Top view of Gear Arrangement

We have the center to center distance from gear2 to gear3

AB=sqrt(27^2+32^2) =42mm

The gear ratio between the gears is 3:4.

So from the figure: r+r+1.5r=42

r=12

So the pinion gear is of diameter=18mm

The driven gear diameter=24mm

Gear material:

Stainless steel series 316

C=.2%,si=2%,mn=2%,cr=23%,ni=13%,s=.05%,p=.05%

Rockwell hardness no.=65

Y=$1.9*10^{-5}$N/mm^2

Tensile strength=618.297N/mm^2

Yield strength=310N/mm^2

Assuming pinion gear to be weaker than the driven gear and the no. of teeth in the pinion gear to be (Z_p)=18

So the module =D_p/Z_p =18/18 =1.

No of teeth for the driven gear

Z_d=(4/3)*18=24.

The module for the driven gear

D_d/Z_d=24/24=1

Center to center distance

a=m(Z_p+Z_d)/2=.5(18+24)=21

Addendum=1mm

Dedendum =1.25 mm

Clearance=.25mm

Tooth thickness=1.5708mm

Fillet radius=.4 mm

6.3.2: - Estimation of module based on wear strength

$m=(60*10^{6/3.14}((P*Cs*Fs)/(Zp^2*Np*Cv(b/m)*Q*k)))^{(1/3)}$

Fs=2(from design data book)

Cs=1.25

P=power in kw=T*w=2*40*2*3.14/60=10w=.01kw

Zp=18

Np=4.186 degree radian/sec

Cv=3/(3+v)=.09875

b/m=10

Q=2*Zg/(Zg+Zp)=2*24/(24+18)=1.142

m=(60*10^6/3.14((.01*1.25*2)/(18^2*40*.9875(10)*1.142*.1444)))^(1/3)=.5184

For pinion

Lewis form factor

y=.154-.912/z

. =.154-.912/18=.103

y = Y / 3.141

Y=.308for 20 degree involutes

σ_{ut}=560N/mm2

σ_{yp}=373N/mm2

X= σ_{ut} /2=373/2=186.6

Strength of gear tooth

Fs=X*b*Y/Pd

=186.6*1*.308/1=57.4N

Transmitted load

$Vm=((3.14*Dp*n)/(60*1000)) =((3.14*18*41)/(60*1000))=.03768m/s$
$Ft=P/Vm=10/.03768=266N$
$Cv=3+Vm/3 =1.01256$
Transmitted load=10*75/(746*.0376)=26.68kgf=262N
Dynamic load
$Fd=Ft*Cv=262*1.01256$
$=265.3N$

6.3.2- Surface endurance limit check

$\sigma=Cr*HRC*Kcl$
Cr=310, HRC=65, Kcl= (10) ^ (1/6)
$\sigma =310*65*(10)^{(1/6)}$
$=2898.46N/mm^2$
Life in no of cycle $=10^7$
So Kcl=1
For high strength alloy nickel chromium steels =1974.7
Taking a factor of safety 2
$\sigma =937.35$
$k=x^2*\sin(20)(1/193064.84)*2$
$=(10075)^2*\sin(20)(1/193064.84)$
$=25.175$

For Wear load
$F_w=Dp*Q*k*b=18*1.142*25.17*b*9.81$
$=507.56*b$
For grade 7
$e=8+.63Y$
$Y=m+.25(Dp)^{1/2} \quad =1+.25(18)^{1/2}$
$=9.2982*10^{-6}$
So e=.009298
For 20 degree full depth involute
$C=11860*e$
$C=11860*.009298$
$=110.27$
$Fd=Ft+(.164*2.2176*(110.27*b+27)/(.164*2.2176+1.485*(110.27b+27.08)^{1/2})$

As for a gear to be stable the dynamic load applied should be lesser than the applied load so
51.74*b>27.+(.3708*(110.27*b+27)/(.3708+1.485*((11027+27.08))^.5
So by putting b=.7cm we get 36.218>33

So the minimum thickness of the gear=7mm
As F_d<F_w
Hence design is safe.

6.3.3:- Design of spring

Material=ss316 stainless steel
Maximum ultimate tensile stress=515mpa
Yield point stress=315mpa
Maximum shear stress=616mpa
Factor of safety=3
Shear modulus of materil=$65*10^9$

P=1.2N
N=no of coils=9
G=$65*10^9$
D=11mm=.011m
δ =.013m
δ =$8*p*C^4$ N/GD, putting all thse values
C=18.11
C=D/d
d=D/c =0.011/18.11
=0.6mm

let we have taken d=.9 mm
ζmax=$(8*P*D*Kw)/(3.14*d^3)$
Kw=(4* C-1)/(4C-4)+.615/C
But c=18.11
Putting the value of C
Kw=1.077
ζmax=$(8*P*D*Kw)/(3.14*d^3)$
putting the Kw and all the values

ζmax=49mpa,which is less than maximum shear stress
hence design is safe

Design of pins for the bottom circular plate:

Material: alloy aluminum

σ_{yp} = 317.104N/mm2

f.s=3

σ_{yp} = σ_{yp}/2=160N/mm2

σ_{all} = σ_{yp}/3=105.7N/mm2

σ_{all} = σ_{yp}/3=53.33N/mm2

Torque is applied to the screw=.5 Nm ,this torque is transmitted at a distance of 9mm from centre.

Force applied on the pin=.95/.oo9=105.55N

Check for shear stress

σ_{all}=F/(3.14*d2/4)

d= sqrt(4*F/(3.14* σ_{all}))~1.8mm

So d can be taken as 3.5mm.

6.3.4: - Check for bending stress

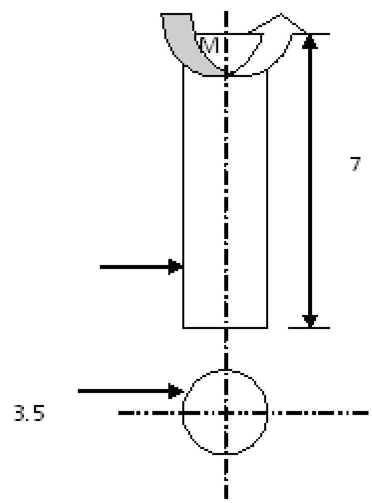


Fig 12: Front view of the circular plate

As shown in the fig. 12

Moment at the circular plate due to the application of 55.55N load (M) =6*105.55=633.3Nm.

y=1.75

I=3.14*d4/64=7.36 mm4

σ =M*y/I=633.33*1.75/7.36=150N/mm^2

as σ> σ_{all} so d can be increased to 4mm

σ =100.5N/mm^2 when d=4.mm.

Chapter 7

Working Principle

7.1 - Design 1(With 4 Pneumatic Cylinders)

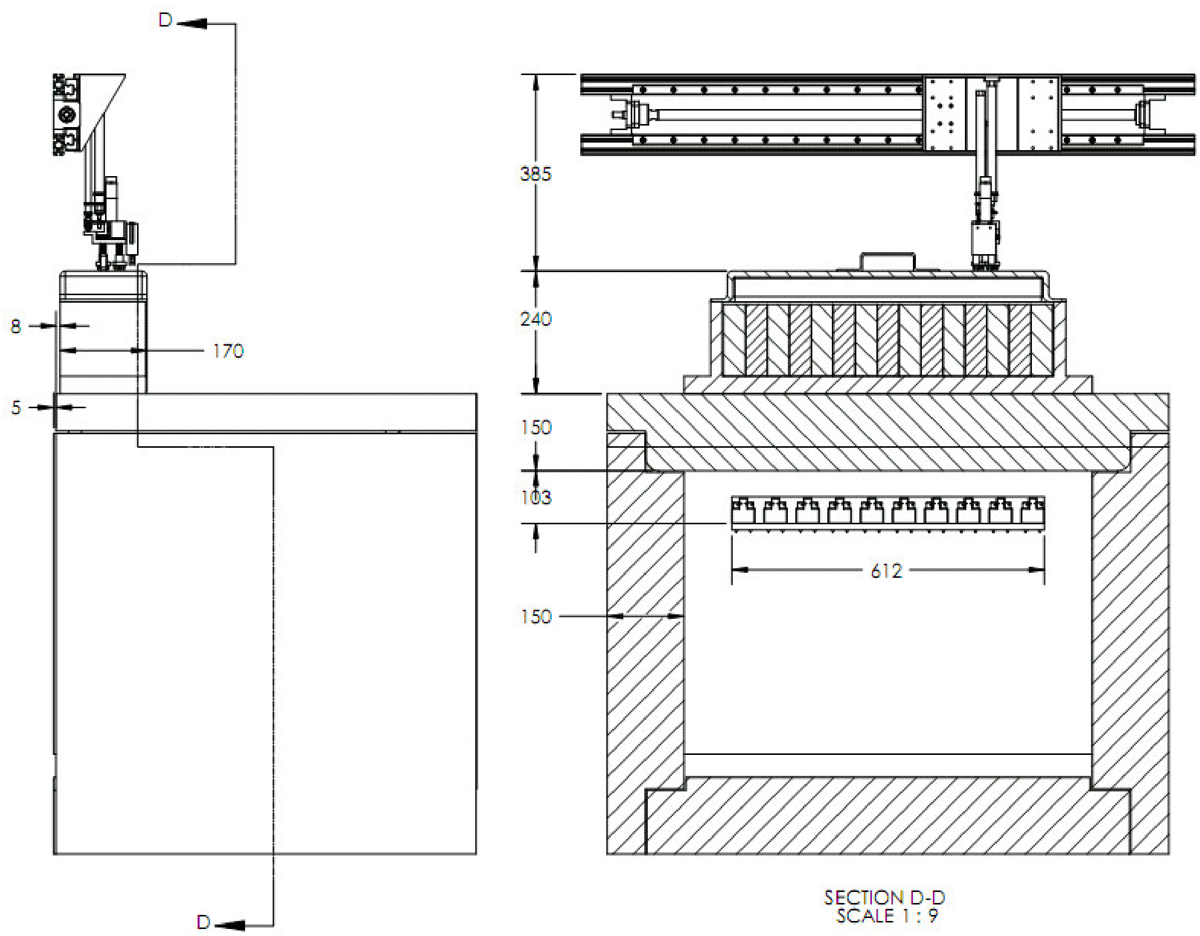


Fig 13: Design 1 with full accessories

7.1.1:-Working principle

This mechanism contains 4-nos. of pneumatic cylinders. First, one pneumatic cylinder is mounted in downward direction with its back clamped to the top LM-Block assembly. The piston of the pneumatic contains threads which can be screwed to another by means of a connector plate. The connector plate is fabricated with one taped hole and one simple hole placed some distance apart. In the tapped hole the piston of the 1st pneumatic is screwed and in the other one the cylinder of the 2nd pneumatic is tightened with a nut. To minimize the moments and forces acting on the 1st cylinder-piston a guide-ring is used. The guide ring contains two holes which correspond to the outer dimensions of the pneumatic cylinders 1 & 2. Similarly the 3rd cylinder is connected to the 2nd one and the 4th cylinder is connected to the 3rd one.

These pneumatic cylinders are properly chosen to sustain all the loads and moments acted on the piston rod. In order to restrict rotational degree of freedom of the piston around the cylinder Q-type model are chosen where the piston is square in shape.

The piston of the 4th cylinder is connected to the lower unscrewing assembly and the gripper. When the 1st pneumatic cylinder is activated its piston advances to acquire a length equal to its stroke. Since the 2nd cylinder is connected to the 1st cylinder-piston it moves downward with the other 2 pneumatic cylinders connected to it. Gradually when all the pneumatic cylinders are activated the lower assembly reaches to the component. The gripper then holds the component with its grips and the unscrewing mechanism starts unscrewing the bolts. Since the rpm of the unscrewing motor is fixed it will take certain time for unscrewing. After this previously calculated time the retraction of the pneumatic starts and the lower assembly moves up holding the component. The whole assembly is move to the horizontal direction with the help of the LM guide and Ball screw assembly to a position where old component are kept and the new component are taken. This fresh component is brought to the required position and the bolts are tightening to the holder base. The whole arrangement is show in figure 13.

7.2 - Design 2(With 2 Pneumatic linear Drives & 1 Pneumatic cylinder)

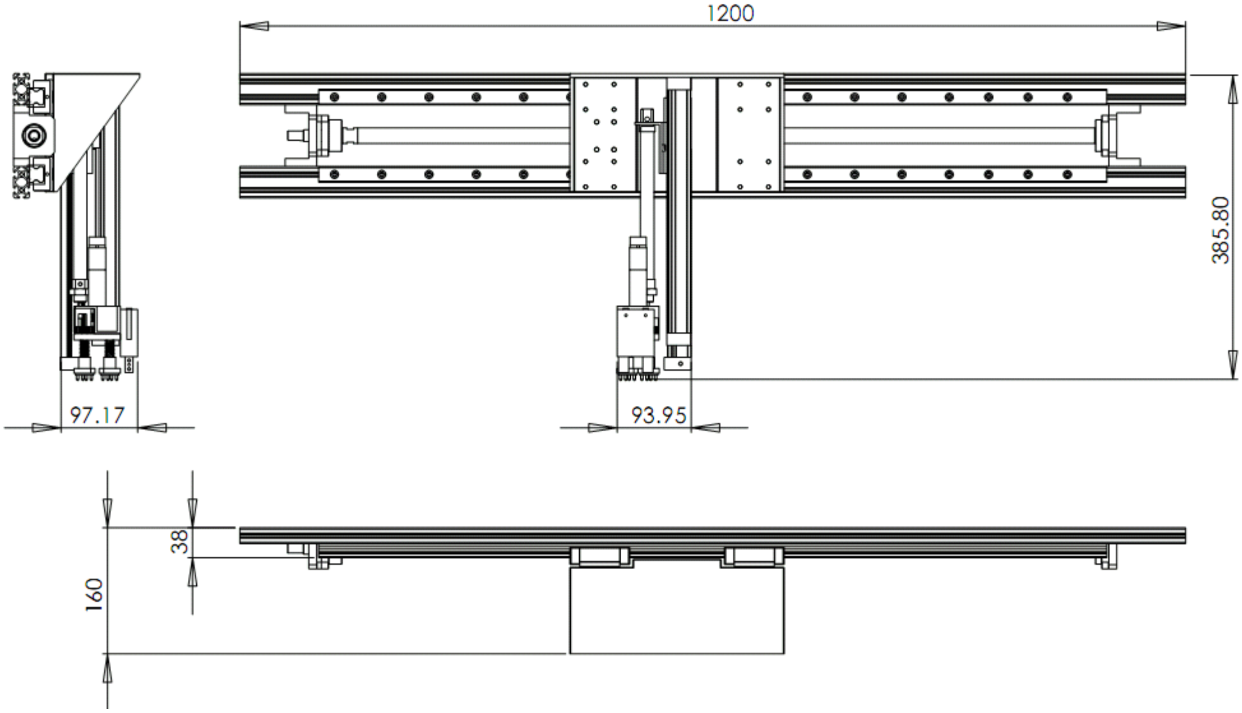


Fig 14: A layout of Design 2

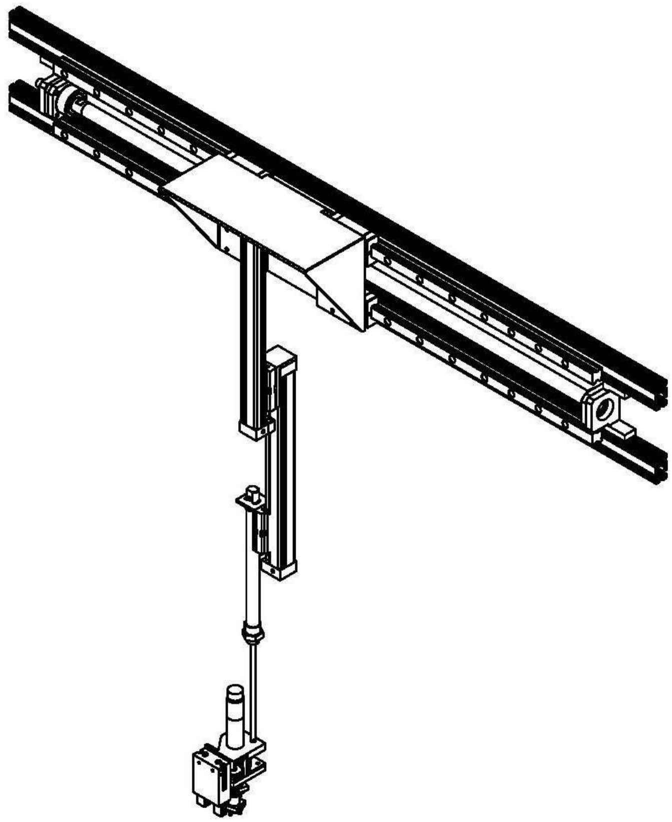


Fig 15: Isometric view of Design 2(Expanded view)

7.2.1: -Working principle

This mechanism contains 2-nos. of pneumatic linear drive and one pneumatic cylinder which is connected to unscrewing assembly and pneumatic gripper. First, one pneumatic linear drive is mounted in downward direction with its back clamped to the top LM-Block assembly. Pneumatic linear drives are interconnected to the each other with the help of a plate (L shape) which is mounted on the slide of the 1st one pneumatic linear drive and other portion is mounted on the top face of 2nd pneumatic linear drive which is mounted in the downward direction. The 2nd pneumatic linear drive is connected to the pneumatic cylinder by the means of different plate (L shape) which is mounted on the slide of the 2nd one pneumatic linear drive and other portion is mounted on the top face of the pneumatic cylinder with the help of screws.

These pneumatic linear drive and the pneumatic cylinders are properly chosen to sustain all the loads and moments acted on the piston rod and the slide portion of the pneumatic linear drive. The pneumatic cylinder presented in the assembly is connected to the lower unscrewing assembly and the gripper. When the 1st pneumatic linear drive is activated its piston advances to acquire a length equal to its stroke. Since the 2nd pneumatic linear drive is connected to the 1st pneumatic linear drive it moves downward with the pneumatic cylinders connected to it. Gradually when all the pneumatic cylinders are activated the lower assembly (unscrewing assembly and pneumatic gripper) reaches to the component. The gripper then holds the component with its grips and the unscrewing mechanism starts unscrewing the bolts.

After unscrew the bolts from the desired portion the whole assembly moves up holding the component. The whole assembly is move to the horizontal direction with the help of the LM guide and Ball screw assembly to a position where old component are kept and the new component are taken. This fresh component is brought back to the required position and the bolts are tightening to the holder base.

The layout of the whole assembly is give in the figure 14 & figure 15 as assembled and expanded way respectively.

Product Description of pneumatic linear Drive

The distinguishing features of the DGC rod less drive with linear guide are as follows:

- Low space requirements
- High dynamic response
- High torque resistance
- High rigidity
- Near zero leakage.

Position sensing: using proximity sensors, built into profiled tube
Additional slide: either right and/or left
Protected recirculating ball bearing guide - GP

7.3- Design 3(Robotic Arm Mechanism)

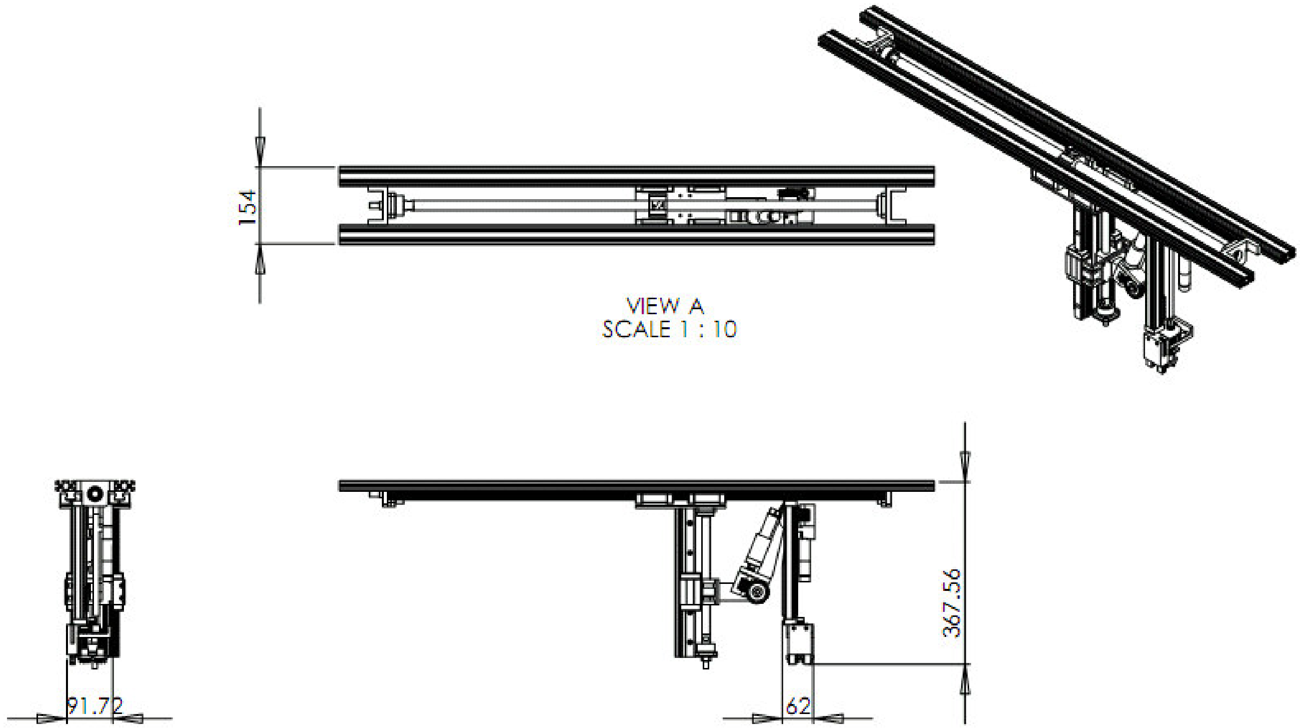


Fig 16 : Compressed view of Design 3

7.3.1:- Working mechanism

The whole layout of the proposed design is given in the figure 16 in compressed position i.e., initial position. At the initially position the LM block that hold the robotic arm is kept at the certain calculated distance from the top assembly. One of the link ends is fixed to the vertical. LM blocks and ball screw by means of a specially fabricated plate. In the other end a hole is present to allow revolute joint with another link that is free to rotate along that axis by means of ball bearings. The other end of the ink is fabricated in the similar fashion to allow another revolute joint with 3rd link. Pneumatic linear drive is attached to the third link and at the end of the pneumatic linear drive unscrewing assembly and pneumatic gripper is mounted. The rotation of the links is achieved by means of worm gears and motors.

At the outset the pneumatic linear drive moves downwards there by taking the unscrewing assembly inside the box. Then the 1st and 2nd worm gears are acted simultaneously in the opposite direction so as to reduce vertical movement of the third link. Simultaneously the LM blocks or the 1st link moves upwards .when the LM block reaches at its top position the second link will be inclined downwards. At this point the worm gears are stop and again the LM block assembly moves downwards.

In the unscrewing mechanism the gears are rotated with the help of a flexible shaft flexible shaft is attached to the motor at the top of the vertical assembly.

The gripper then holds the component with its grips and then unscrewing mechanism starts unscrewing the bolts.

After unscrew the bolts from the desired portion the whole assembly moves in the reverse fashion holding the component. The whole assembly is move to the horizontal direction with the help of the LM guide and Ball screw assembly to a position where old component are kept and the new component are taken. This fresh component is brought back to the required position and the bolts are tightening to the holder base.

7.4-Design 4(Scissor Mechanism)

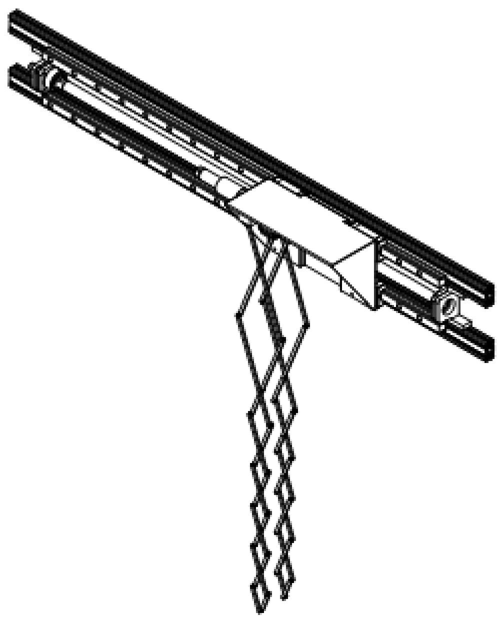


Fig 17: Isometric View of Scissor Mechanism

7.4.1:-Working mechanism

This mechanism consist of no seven pair of links to make the structure stable there are two pair of such arrangement which are interconnected with the help of small cylindrical rod the links make an angle of 150 degree When it is in the compressed position and at the time of expansion it will be at 30 degree with each other. Two of the top most links are fixed to a hinged support and other two are free to slide on miniature LM guide. The free ends are moved by the help of a Ball screw arrangement which is driven by a geared DC motor. The isometric view of the given design is given in figure 17.

Initially the arrangement is at its compressed position when the DC motor is rotated in the clockwise direction the free end moves towards the fixed end of the top link as a result the distance between the links decreases gradually and the lower unscrewing assembly moves downward. At the maximum position the angle between the links becomes 30 degree at this position the top motor stops. Then the pneumatic gripper holds the component and the unscrewing of the bolt are started. When the bolts are fully unscrewed the lower assembly moves upward holding the component with it. Then the whole assembly is traveled horizontally by means of LM guide and ball screw arrangement to a position where it can drop the old component and take a new one for replacement. The fresh component is taken and tightens to its required position.

7.5 - Design 5(Telescopic Tube Mechanism)

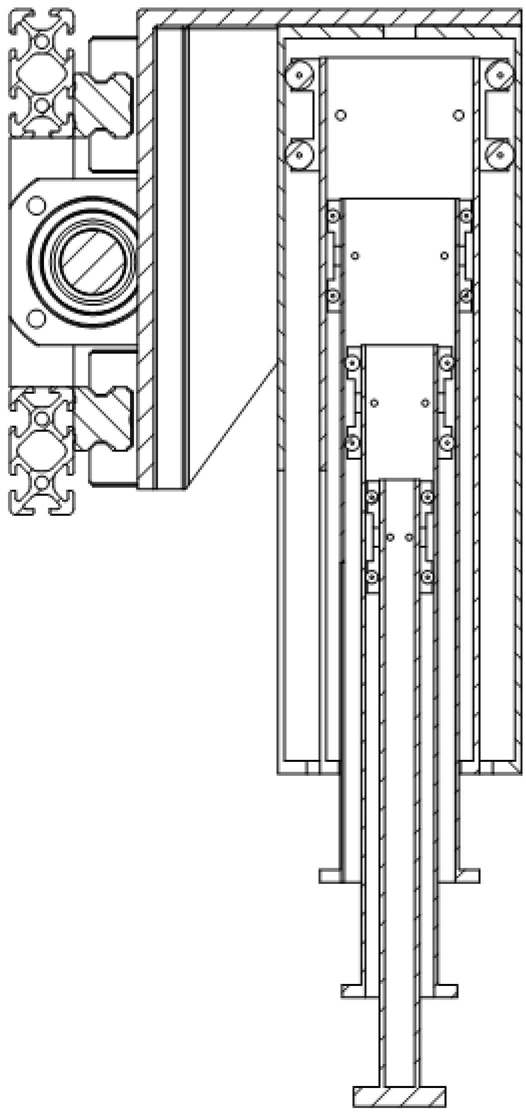


Fig 18 : Section view of Telescopic tube mechanism

7.5.1:-Working principle

This design consists of 5 square tubes of different dimensions which are placed coaxially.ut of the proposed design is given in the figure 18. The unscrewing arrangement is attached to the end of bottom most tube. The unscrewing plate also holds the pneumatic gripper, which is used to grip the needle clip valve assembly. From these 5 cylinders the top one of cross-sections equals to the recirculating ball screws and LM blocks. The recirculating ball screw provides the horizontal motion for accurate positioning of the arrangement above theneedle clip valve assembly. The LM guide ways helps in guiding the plate on both sides.The tube 5 is connected with a wire rope. This wire rope is then taken to the top through the hollow pathways and is attached to a pulley which is coupled to a dc geared motor.

The mechanism works on the principle of gravitation. The actuation depends on the amount of load at the bottom and the rpm of the motor. So first the arrangement is in its compressed position with a length within 350 mm from the top. When the motor rotates the wire wound around its circumference is released and whole arrangement moves down due to its weight. To have frictionless motion cylindrical rollers are provided between the sliding parts of the tube. While moving upwards the pulley has to rotated in reverse direction as a result the wire rope gets wound back to its normal position. During the upward motion, first the tube 5 gets lifted, when the outward projection of tube 5 comes in contact with the end of tube 4 it transmit the upward motion to it and both the tubes moves simultaneously upward. This process then contiunese for the rest tubes till tube no.1 comes in contact.

Chapter 8

Comparative Study (Physical Aspects)

8.1.- Design 1(With 4 Pneumatic Cylinders)

Design 1 is consisting of following component and its layout is given in figure 19.

1. LM guide arrangement
2. DSAG-16-135-P-A (Pneumatic cylinder)
3. DSAA-16-135-P-A (Pneumatic cylinder)
4. DSAA-10-155-P-A (Pneumatic cylinder)
5. DSAA-10-130-P-A (Pneumatic cylinder)
6. Unscrewing arrangement
7. Pneumatic gripper

Significance of the Code (DSAG-16-135-P-A)
DSAG – Pneumatic standard cylinder
16 - Piston diameter (mm)
135 - Stroke length (mm)
G - Basic design
P - Flexible cushioning, non-adjustable
A - For proximity sensors

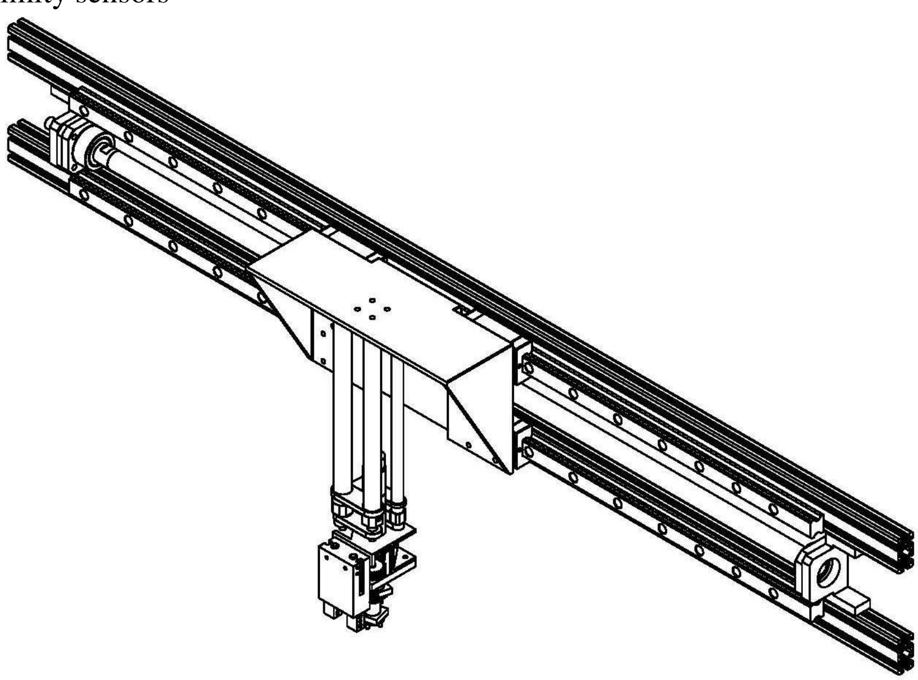


Fig 19: A Isometric view of Design 1

Silent feature of the Design: -

- ✓ The proposed design is consists of 4 pneumatic drives to reach to the desired position.
- ✓ Degree of freedom for this design is one.
- ✓ Initial space covered by this design is 362 mm from the top and the maximum stroke that can achieve by this design is 614 mm.

8.2 -Design 2(With 2 Pneumatic linear Drives & 1 Pneumatic cylinder)

Design 2 is consisting of following component & its isometric view is shown in figure 20

1. LM guide arrangement
2. DGC-12-215-G-P-A (Pneumatic linear drive (Rod less cylinder))
3. DGC-12-215-G-P-A (Pneumatic linear drive (Rod less cylinder))
4. DSN-16-155-P-A (Pneumatic cylinder)
5. Unscrewing arrangement
6. Pneumatic gripper

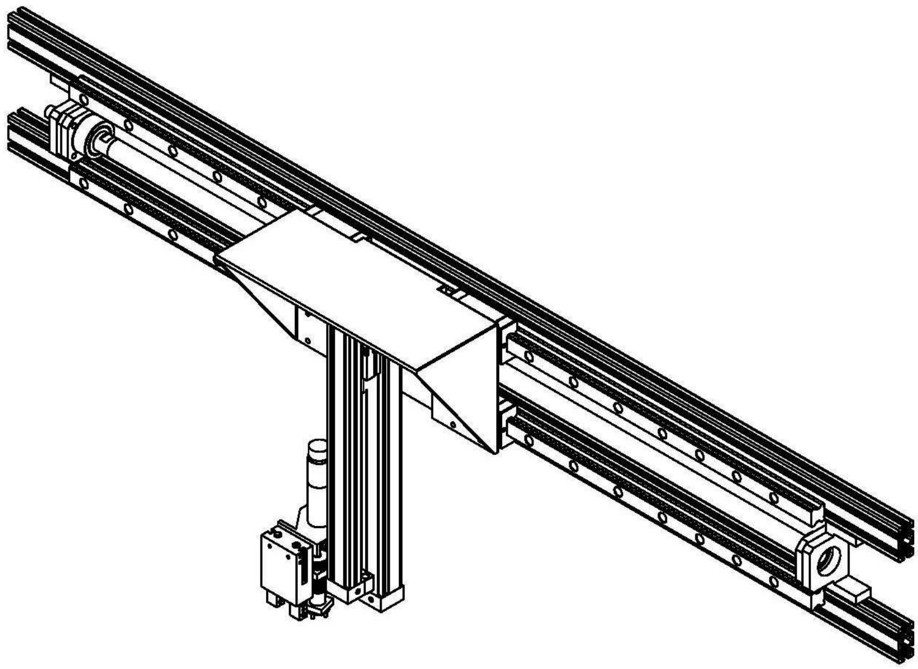


Fig 20 : A Isometric view of Design 2

Significance of the Code **DGC-12-215-G-P-A**

DGC – Pneumatic linear unit
16 - Piston diameter (mm)
215 - Stroke length (mm)

G - Basic design
P - Flexible cushioning, non-adjustable
A - For proximity sensors

Stroke length = 215 mm
Overall length = 340 mm
Total weight of the product (DGC-12-215-G-P-A) = 270 + 12* 215= 2,850 gm
Significance of the Code **DSN-16-155-P-A**
DSN – standard pneumatic cylinder
16 - Piston diameter (mm)
155 - Stroke length (mm)
P - Flexible cushioning rings/Plates at both ends
A - For proximity sensors

Stroke length = 155 mm
Overall length = 266 mm
Total weight of the product (DSN-16-155-P-A) = 96 + 4.7* 155
= 824.5 gm

Silent feature of the Design: -

- ✓ The proposed design is consists of 2 pneumatic drives and 1 pneumatic cylinder to reach to the desired position.
- ✓ Degree of freedom for this design is one.
- ✓ Initial space covered by this design is 382 mm from the top and the maximum stroke that can achieve by this design is 585 mm.
- ✓ Proposed design is simple and easy to handle.

8.3 -Design 3(Robotic Arm Mechanism)

This mechanism consists of

1. LM guide and Ball screw arrangement
2. Single robotic arm
3. Pneumatic linear drive (DGC- 08-150-G-P-A)
4. Unscrewing arrangement
5. pneumatic gripper

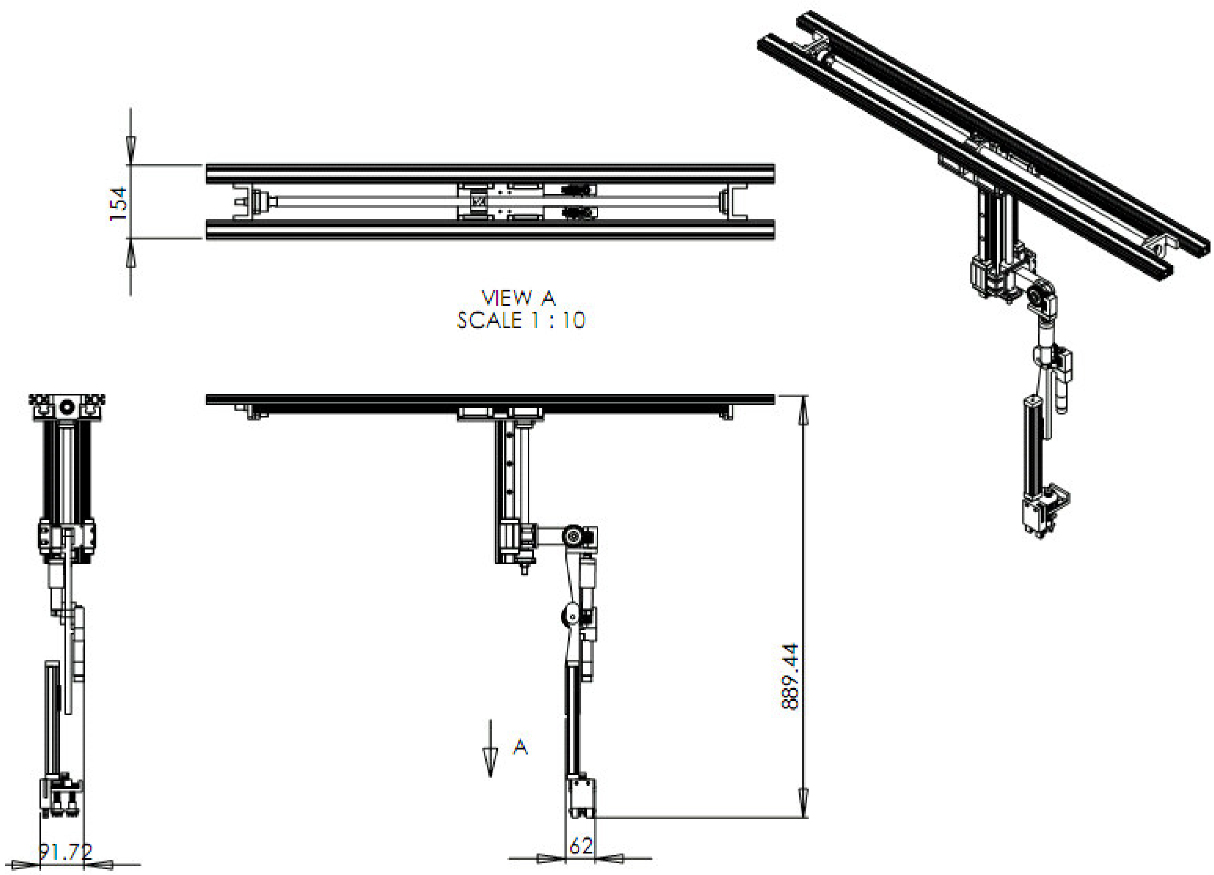


Fig 21: Expanded view of Design 3

Silent feature of the Design: -

- ✓ The proposed design is consists of 1 pneumatic drives & a robotic arm to the desired position.
- ✓ Initial space covered by this design is 382 mm from the top and the maximum stroke that can achieve by this design is 525 mm.
- ✓ With the help of the proposed design we can reach at any position inside the blister box.

8. 4-Design 4(Scissor Mechanism)

Design 4 is consisting of following component

1. LM guide arrangement
2. No. of links
3. Unscrewing arrangement
4. Pneumatic gripper

Expanded view of the proposed mechanism is given in the fig 22.

Silent feature of the Design: -

- ✓ The proposed design is working on the principle of a scissor.
- ✓ This design is easy to use and its repeatability will be more as compare to other designs.

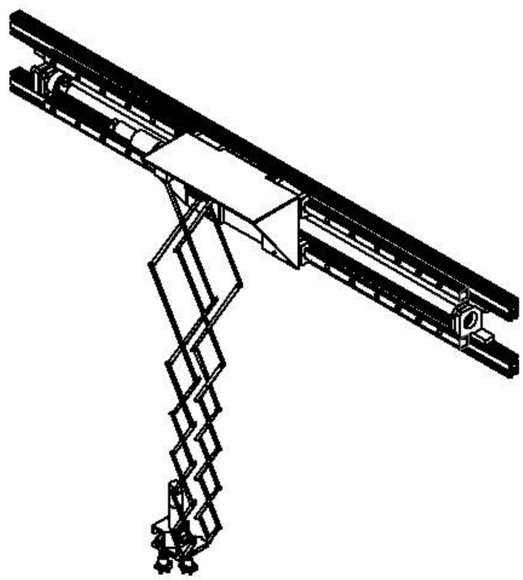


Fig 22: expanded view of the scissor mechanism

8. 5 -Design 5(Telescopic Tube Mechanism)

Design 5 is consisting of following component

1. LM guide and ball screw arrangement
2. 5 square tubes
3. Pneumatic gripper
4. Unscrewing arrangement

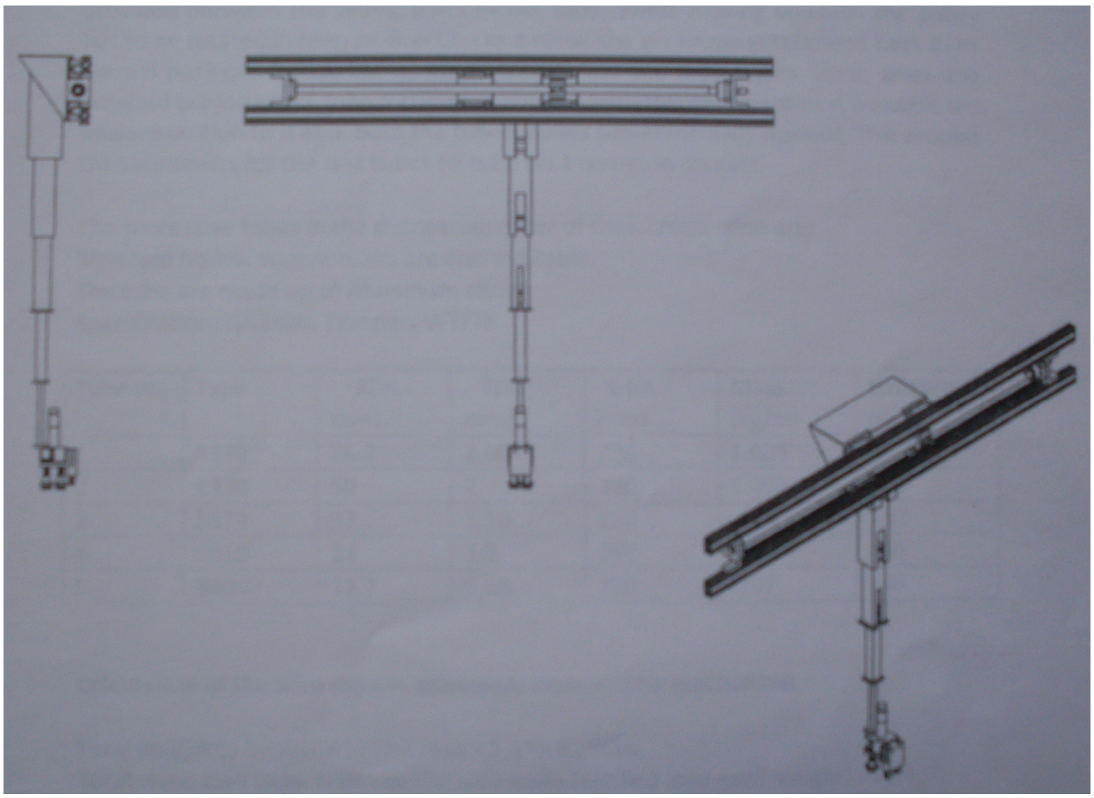


Fig 23: View of the Design 5

Chapter 9

Comparative Study (Kinematic and Dynamic)

9.1- Design 1(With 4 Pneumatic Cylinders)

DSAG-16-135-P-A

Significance of the Code
DSAG – Pneumatic standard cylinder
16 - Piston diameter (mm)
135 - Stroke length (mm)
G - Basic design
P - Flexible cushioning, non-adjustable
A - For proximity sensors

Weight of the product DSAG-16-135-G-P-A = 96 + 4.7* 135
= 634.5 gm
Weight of the product DSAA-16-135-G-P-A = 35 + 4.9* 135
= 634.5 gm
Weight of the product DSAA-10-155-G-P-A = 43 + 2.3* 155
= 399.5 gm
Weight of the product DSAA-10-130-G-P-A = 43 + 2.3* 130
= .342 gm

Weight of the component = 1000 gm
Weight of the lower assembly (unscrewing assembly + pneumatic gripper) = 1000 gm

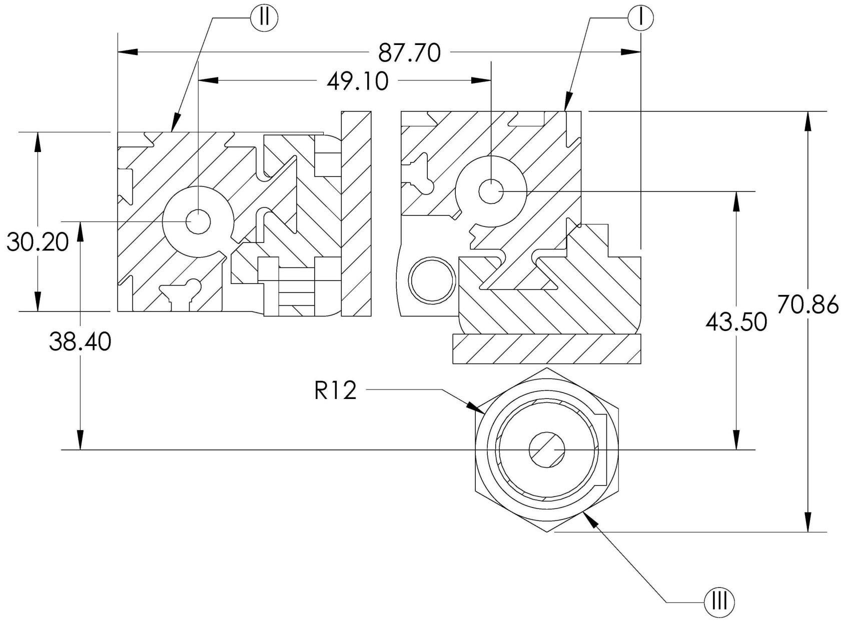
9.2-Design 2(With 2 Pneumatic linear Drives & 1 Pneumatic cylinder)

Calculation of Forces and Torques

Table 1 is for the Permissible Forces and Torques presented in DGC-12-215-G-P-A

Piston diameter Ø	12
F Y(Max) [N]	300
F Z(Max) [N]	300
M X(Max) [N-m]	1.3
M Y(Max) [N-m]	5
M Z(Max) [N-m]	5

Table 1: Calculation of Forces and Moments for Design 2



Notations present in the above diagram

I – pneumatic linear drive (DGC-12-215-G-P-A)
II-pneumatic linear drive (DGC-12-215-G-P-A)
III – pneumatic cylinder (DSN-16-155-P-A)
Total weight of the DGC-16-155-P-A = 824.5 gm
Total weight of the DSN-12-215-G-P-A = 2,850 gm
Total weight of the pneumatic gripper and the unscrewing arrangement = 2,000 gm

Calculation for I pneumatic linear drive

M_Y = (weight of III + weight of the pneumatic gripper & unscrewing arrangement) * acceleration due to gravity) * (distance between the centers of two product)

= 2.825*9.81*.04350

=1.205N-m

$M_X = M_Z = 0$ N-m

Calculation for II pneumatic linear drive

M_Y = (weight of I + weight of III + weight of the pneumatic gripper & unscrewing arrangement) * (acceleration due to gravity) * (distance between the centers of two product)

= 5.675*9.81*.091

= 2.733 N-m

M_X = (weight of III + weight of the pneumatic gripper & unscrewing arrangement) * (acceleration due to gravity) * (distance between the centers of two product)

= 2.825*9.81*.03840

=1.06N-m

M_Z = 0 N-m

Calculated moments are within the range so **Design is safe.**

9.3- Design 3(Robotic Arm Mechanism)

9.3.1:-Worm Designing calculation

m = axial module = 1.5

n_1 = input speed = 255 rev/min (worm)

n_2 = output speed = 8.5 rev/min (wheel)

R g = reduction ratio = n_2 / n_1 = 30

a = centre distance = 30 mm

z 1 = Nearest number to (7 + 2,4 SQRT (a)) /R g = .67

Lets take it 1

z 2 = Next number < R g . z 1 = 30

Using the value of estimated centre distance (a) and No of gear teeth (z 2)obtain a value for q from the table

q = 1

d 1 = q.m = 9.5*15

= 14.25 = 14

d 2 = 2.a - d 1= 60-14.25

=45.75 =45

Worm wheel face width b a =2*m*SQRT (q+1) = 9.7

Normal pressure angle $\alpha_n = 20^o$

γ = worm lead angle at mean diameter = tan-1 (z 1 / q)

= 6 ^{o}

b_l = Length of worm wheel = 14*m (mm)

= 21 mm

c = clearance

c_{min} = 0,2.m cos γ = .2*1.5*cos6 = .32 mm

c_{max} = 0,25.m cos γ (mm) = .25*1.5*cos6 = .373 mm

$d_{a.1}$ = Tip diameter of worm
= d 1 + 2.h a.1 (mm)
= 17 mm
$d_{a.2}$ = Tip dia worm wheel (mm)
=47 mm

$h_{f.1}$ = Worm Thread dedendum
Min = m.(2,2 cos γ - 1) =1.5*(2.2*cos6 - 1)=1.78 mm
Max = m.(2,25 cos γ - 1)(mm)=1.5*(2.25*cos6 - 1)= 1.856 mm
Min = Normal module = m cos γ(mm)=1.48=1.5mm

p x = Axial pitch of worm threads and circular pitch of wheel teeth
=the pitch between adjacent threads = π. m. (mm)
= 4.71 mm
p n = Normal pitch of worm threads and gear teeth (m)
p z = Lead of worm = p x. z 1 (mm)
=4.71 mm

R g = Reduction Ratio = 30 mm
μ = coefficient of friction = 0.08 , as sliding speed = 0.2

Tangential force on worm (F wt)= axial force on wormwheel
F wt = F ga = 2.M 1 / d 1
= 2* 1.17/14*10^{-3}
= 167 N
Axial force on worm (F wa) = Tangential force on gear
F wa = F gt = F wt.[(cos α n - μ tan γ) / (cos α n . tan γ + μ)]
= 167((cos 20 – 0.07 tan6)/cos 20 –tan6 + 0.08)
= 870 N

Output torque (M 2) = Tangential force on worm wheel * Worm wheel reference diameter /2
M 2 = F gt* d 2 / 2
= 19.57 Nm
Relationship between the Worm Tangential Force F wt and the Gear Tangential force F gt
F wt = F gt.[(cos α n . tan γ + μ) / (cos α n - μ tan γ)] = 321.27 N

9.3.2:- Efficiency of Worm Gear (η)
η = [(cos α n - μ tan γ) / (cos α n . tan γ + μ)] / cot γ
= [(cos α n - μ .tan γ) / (cos α n + μ .cot γ)]
= 0.547

Sliding velocity (V_s) (m/s)

$V_s = 0{,}00005236.\ d_1.\ n_1 \sec\gamma$

$= 0{,}00005235.m.n\ (z_1^2 + q^2)$

$= 0.188$m/s

Peripheral velocity of wormwheel (V_p) (m/s)

$V_p = 0{,}00005236{,}d_2.\ n_2$

$= 0.02$ m/s

9.3.3:- Permissible Load for Strength

The permissible torque (M in Nm) on the gear teeth is obtained by use of the equation

$M_b = 0{,}0018\ X_{b.2}\ \sigma_{bm.2.}\ m.\ l_{f.2.}\ d_{2.}$

$X_{b.2}$ = speed factor for bending (Worm wheel)

$\sigma_{bm.2}$ = Bending stress factor for Worm wheel

$l_{f.2}$ = length of root of Worm Wheel tooth

d_2 = Reference diameter of worm wheel

m = axial module

γ = Lead angle

Permissible Torque for Wear

The permissible torque (M in Nm) on the gear teeth is obtained by use of the equation

$M_c = 0{,}\ 00191\ X_{c.2}\ \sigma_{cm.2}.Z.\ D_2^{1,8}.\ m$

$X_{c.2}$ = Speed factor for wear (Worm wheel)

$\sigma_{cm.2}$ = Surface stress factor for Worm wheel

Z = Zone factor.

Radius of the root = $R_r = (d_1/2 + h_{ha,1}\ (= m) + c(= 0{,}25.m.\cos\gamma)$

$= (14/2 + 1.5 + 0.25 * 1.5 \cos 6)$

$= 8.874$

$l_{f.2} = 2.R_r.\sin\text{-}1\ (2.R_r / b_a)$

$=2*8.873*\sin^{-1}(8.873/10)*phi/180$

$= 19.37$ mm

Speed Factor for Bending =0.56 or 0.57

$M_b = 0.0018*0.57*69*19.37*1.5*45$

$=92.56$ N-m

9.4 -Design 4(Scissor Mechanism)

9.4.1:- Design process

SELECTION OF ALUMINIUM BARS

Table 2 : Type of Bars used in Design 4

Sl no.	Type	Length	dimension	No. of parts
1	5220	230	6.4x3	4
2	5220	210	6.4x3	4
3	5220	122.5	6.4x3	4
4	5220	105	6.4x3	15

Table 2 represent the different type of bars that we are using for our design , here we are using the aluminum alloy as material.

Tensile strength= $4.205070 * 10^8$ N/mm^2

Yield strength = $3.17104 * 10^8$ N/mm^2

Density = 2800 Kg/ m^3 ,μ= 0.33,γ = $7.4 * 10^{10}$ N/mm^2

Weight of unscrewing part = 600 gm

Weight of the gripper = 200 gm

Weight of the component = 1000 gm

Weight of the extra accessories = 100 gm

Total weight = 2 Kg

Downward force = 20 N

From the sine law

T/sin (165) = 20/sin (30)

T = 10.36 N

9.4.2:-Checking the tensile stress

σ_t = F/A =10.35/21=.4928N/mm^2

$\sigma_{(allowed)}$=317.104/f.o.s

=317.104/4

=79.276N/mm^2

$\sigma_{(allowed)} > \sigma_t$

Hence deign is safe.

Checking shear strength of the riveted joint

Material=chromium stainless steel

$\zeta_{yp} = \sigma_{yp}/2$ (according to maximum shear stress theory)

$\zeta_{yp(allowed)=}$86.17/f.s =86.17/4 =21.5425 N/mm^2
ζ_{yp}=F/(3.14*d^2/4) =10/(3.14*d^2/4) =21.5425 N/mm^2
d=.77mm
let take d = 1.5mm

Check for crushing load
σ_C * d * l = F
σ_C * 1.5 * 6 = 10.3 = 1.444 N/mm^2
$\sigma_{(allowed)} = \sigma_{yp}$ / 4 = 172.334/4 = 43086 N/mm^2
σ (alowed) > σ_C , hence the design is safe

So the total weight of the arrangement = 20 + (53*16 – 4*2.5) + 4*(65+5) + 4 *160
= 1778 gm

9.5:- Design 5(Telescopic Tube Mechanism)

9.5.1:-Design process
Material=Al alloy
Specification: IS63400,Temper : wt//T_6
A detail of each and every tube is given in table 3 below.

Table 3: Description of different types of tubes used for Design 5

Serial No.	Mass per length (kg/m)	Length(mm)	Actual mass (gm)	Stroke length (mm)	order no	A(mm)	T(mm)
1st one	1.603	230	385	0	8338	76.20	2
2nd one	1/037	220	233.33	170	8330	50	2
3rd one	.426	210	91	160	8473	37	1.10
4th one	.295	200	60	150	9810	24	1.20
5th one	.1978	190	38	140	9405	12.7	1.65

Calculation of the wire rope in telescopic tube mechanism
Total weight to be taken by the rope = 2.3*9.81 = 23 N
Total static load at the end of the wire = applied load + self weight =28N
The load 28 N has to be carried by the pulley

Standard pulley available
Diameter = 40.185mm, Bore Diameter = 8mm

Material: stainless steel

9.5.2: -Selection of motor

Torque required = static load at the beginning of the pulley) radial distance

= 30*0.02=0.6 N-m

Assuming higher torque valve at dynamic load,

We have selected a motor wit torque rating 1.5 N-m

So in 1 revolution distance travel = π*D=3.14*40=126 mm

Total distance to be travel = 585 mm

So no of rotation required =585/126=4.64

So we want to set up to reach the location in 30 seconds so the rpm let be 9.285 rpm .

Reduction available = 742:1

So plaentray gear head GP 22C,Φ22 mm

No. of stages = 5

Efficiency, η = 0.42

The nominal speed of the motor only = 742*9.285 = 6890 rpm

On the basis of the required rpm the motor selected is

EC-max Φ22, 12watt

Nominal speed = 6840 rpm, Nominal torque = 11.4 rpm

Weight = 67g

Torque at the output of gear shaft = 11.4*742*0.42=3.553 N-m

Overall length = motor length + gear head length + tacholength = 94.4

9.5.3:-Calculation of the dynamic load

While motor starts from 0 rpm to 9.23 rpm , it accelerates in the upward direction so the net acceleration in the upward motion is = 9.81+ a

Time taken for this action (t) = 0.5 sec (assumed)

Acceleration, a = (v-u)/t

v = 3.14*0.04*9.28/60 = 0.020 m/s

a = 0.02/5 = 0.04 m/sec^2

a_r = 9.81+0.4 = 9.85 m/sec^2

so the total dynamic force on the wire rope = 9.85*3 = 30.12 N

9.5.4:- Wire Rope selection

Suitable wire rope made o stainless steel 304 may be used for this purpose.

Chapter 9

Conclusion

There five design of manipulator for maintenance of work in hazardous environment is presented. For our case the hazardous environment is radioactive environment. All of them satisfy the required operational and dimensional constraints as per as the problem.

Design 1 is simple and can be used for repetitive times. But it time taken by this manipulator is more as compared to the other design because here user has to very precision regarding the movement and position of the pneumatic cylinders.

Design 2 is modified version of the Design 1 as here we are using pneumatic linear drive (Rod less cylinders) as compare to pneumatic cylinder. Stroke length is more in this case.

Design 3 is the most complicated to design but easy to use as compare to others design. Here there is more degree of freedom. It can access to any part of the blister box easily.

Design 4 is using the mechanism of a scissor for its working which is very easy to use and repetitive work can be obtained from this designed.

Design 5 is simplest among all the design and its working principle is also very simple. So it can work faster and repetitive as compare to others.

All the proposed design is successfully modeled, simulated, designed using software like AUTOCAD, SOLID WORKS. They are all checked for the desired load, deflection, moments, torque and all other necessary parameters for the design. Selected DC geared motors, LM guide, Ball screw, Pneumatic linear drive, Pneumatic cylinders, and Pneumatic gripper are all within the range of operating parameters and given dimensions.

User can selected any of the design as per his own requirement and modified the design of manipulator as per as desired.

Chapter 10

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